



***Astrophysics Technology
Heritage Study
2010-2020***

***Marc Hayhurst
The Aerospace Corporation***

March 31, 2022

Approved for public release. OTR 2022-00559.



Executive Summary

Astrophysics Technology Heritage Study 2010-2020

- The Aerospace Corporation has conducted an independent, comprehensive Astrophysics Technology Heritage Study (2010-2020) for NASA Headquarters Astrophysics Division (APD)
 - *The purpose of the study was to understand the overall impact on astrophysics technology advancement from the grants* issued by NASA's Astrophysics Division*
 - *NASA Technical Official responsible for the study: Mario Perez, APD Chief Technologist*
 - *The study began in May 2021 and a midterm report was delivered September 2021*
 - *Throughout the study Aerospace held biweekly meetings with the NASA APD team to present progress and initial findings*
- The study was organized in three major research areas:
 - I. Grants Database – compilation & analysis of competed astrophysics technology grants 2009-2020*
 - II. Missions Database – space and suborbital missions 2010-Future*
 - III. PI Survey – survey of 300+ technology grant recipients 2009-2020*
- Data analyses were conducted on each database individually and then cross referenced with each other in attempt to assess the overall picture
 - *Grants database includes some non-technology development grants*
 - *Non-technology development grants were excluded from technology specific analyses, but were included in general trend analysis of the entire database*

**Grants refers to all competed grants, RTOPs, and technology development contracts issued by Astrophysics including: APRA, SAT, Roman Technology Fellowships, NESSF/FINESST, and SMTP. Directed technology investment is not included.*



Significant Findings

Astrophysics Technology Heritage Study 2010-2020

- Astrophysics grants and contracts fund a healthy portfolio of technologies that resulted in a 62% infusion rate
 - *Suborbital missions provide ample science and technology maturation and transition opportunities*
 - *Of the 62%, 31% were suborbital missions and 12% were space-based missions that have advanced beyond pre-formulation*
 - *Astrophysics technology development lifecycle is likely longer than 10 years and this percentage would likely be even higher if the prior decade's grants were also considered*
- Grants awarded have numerous alternative benefits beyond the primary purpose
 - *Provides development for students/staff, lab/infrastructure, and more*
- Lack of opportunity for space missions was the top reason given for technology developed using grants not being infused
 - *SMEX/MIDEX opportunities are few and Flagship opportunities are only about once a generation*
- A total of 120 unique organizations received grants, with most receiving only one, but 19 organizations received 58% of all grants
 - *The top two organizations were GSFC and JPL, which received 19% of all grants*
 - *GSFC received 80 grants (10%) and JPL received 71 grants (9%)*
 - *These organizations were followed by CU-Boulder (31 grants, 4%), Caltech (30 grants, 4%), and Penn State University (28 grants, 3%)*



Grants Database Overview

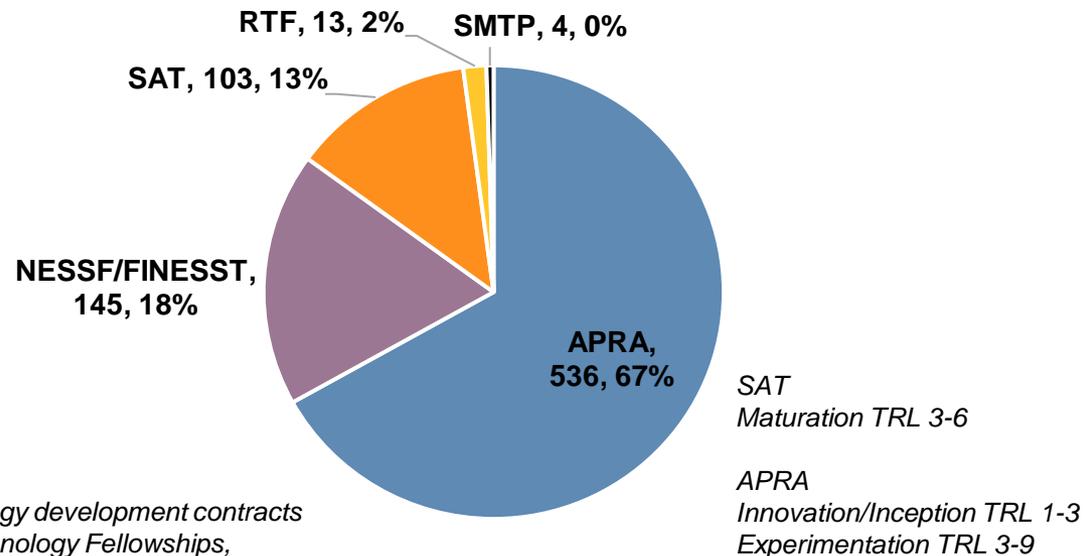
Astrophysics Technology Heritage Study 2010-2020

- Grants* database includes competed grants for the following programs for ROSES years **2009-2020**
 - **APRA, SAT, Roman Technology Fellowships, NESSF/FINESST, and SMTP**
 - *Includes non-technology development grants*

Program	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
APRA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A	✓
NESSF/FINNEST	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓✓	N/A
RTF	N/A	N/A	✓	✓	N/A	✓	✓	N/A	N/A	✓	✓	✓
SAT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N/A	N/A
SMTP	N/A	✓	N/A	✓	N/A							

- Two-thirds of the grants in the database are from APRA
- Database contains:
 - **801 grants**
 - **404 unique PIs**
 - **120 unique organizations**

Grants Per Program



*Grants refers to all competed grants, RTOPs, and technology development contracts issued by Astrophysics including: APRA, SAT, Roman Technology Fellowships, NESSF/FINESST, and SMTP. Directed technology investment is not included.



Missions & Experiments Database Overview

Astrophysics Technology Heritage Study 2010-2020

- Missions & experiments database includes all NASA Astrophysics missions and instruments **flown on or after January 1, 2010**
 - **Both suborbital and space missions are included**
 - Suborbital missions flown multiple times are counted once unless a later flight features a significant change to the mission or instruments
 - Missions **planned to be flown in the future** are included
 - **Kepler and WISE** launched in 2009 but are included in the database
 - **Non-NASA missions** are included if they flew US-contributed instruments

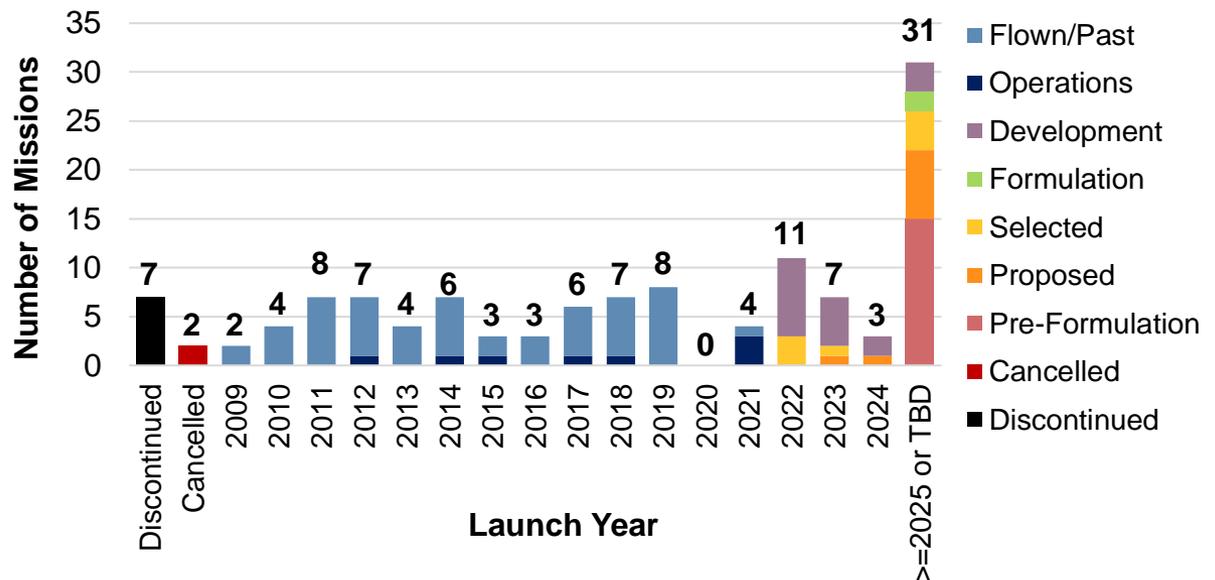
- Database contains:

- **123 missions**

- 9 cancelled or discontinued
- 24 proposed or pre-formulation
- 28 developing or selected
- 62 past or operational

- **207 instruments**

Astrophysics Missions Launched Per Year



For suborbital missions with multiple flights, only the first flight year (on or after 2010) is shown

Grant Infusion Status

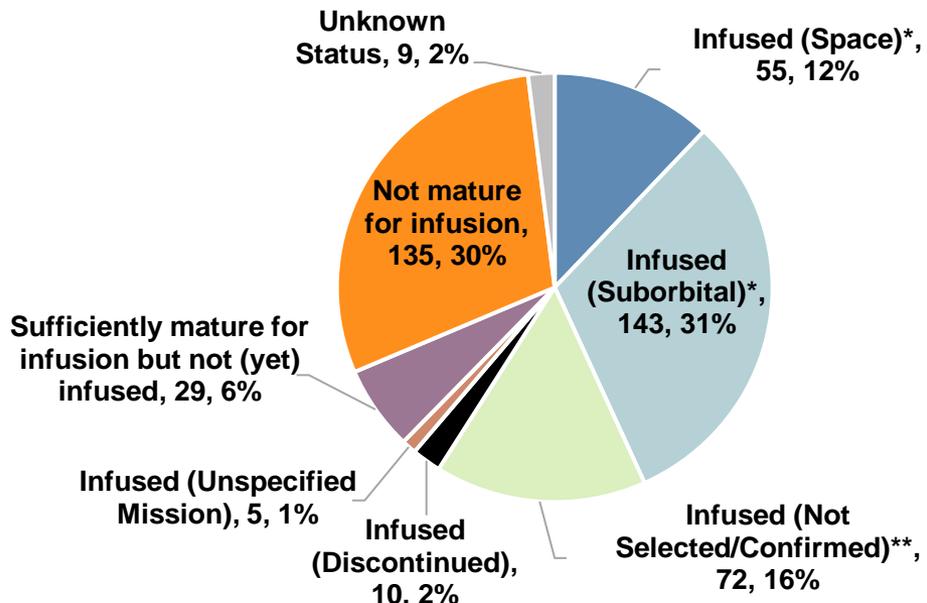
Astrophysics Technology Heritage Study 2010-2020



- **Majority of tech dev grants resulted in infused technologies (285 of 458, or 62% of grants)**
 - Including space (12%) and suborbital (31%)
 - Including pre-formulation and proposed (16%)
- Only 29 grants (6%) resulted in a mature technology that had not been infused

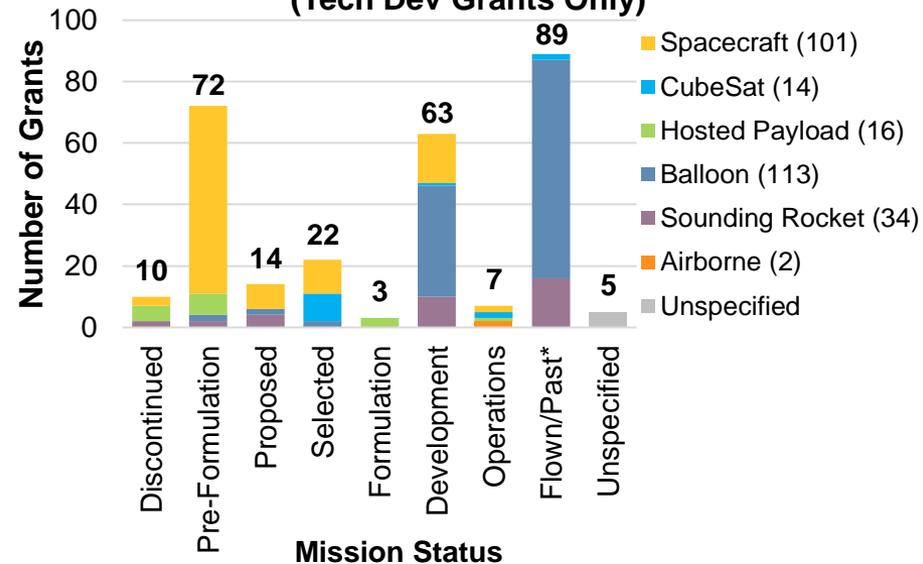
- Infused grants were most likely to contribute to flown/past missions (89 of 285 grants, or 31%), followed by missions in pre-formulation (72 grants, or 25%)
 - **Most past missions were suborbital**
 - **Spacecraft missions were primarily in pre-formulation, selected, or in development**
 - 5 grants were infused into non-Astrophysics missions

Grant Infusion Status – Detailed (Tech Dev Grants Only)



*"Infused Space & Suborbital" includes selected, formulation, development, flown/past
 ** "Not Selected/Confirmed" includes pre-formulation and proposed missions

Infused Grants By Mission Types And Status (Tech Dev Grants Only)



* "Flown/Past" category includes 2 grants for upcoming re-flights of past balloon missions

Numbers represent the number of grants



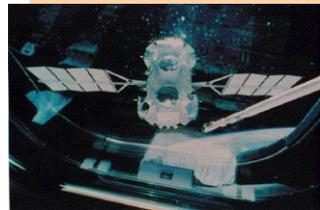
Heritage Example: COSI

Astrophysics Technology Heritage Study 2010-2020

- A Compton telescope with a long heritage tracing back to the COMPTEL instrument onboard Compton Gamma Ray Observatory (GRO), one the four Great Observatories
 - Since 2009, at least 13 NASA Astrophysics grants have supported the development of miniaturized COMPTEL technologies as well as multiple balloon flights, an upcoming COSI SMEX spacecraft mission, and proposed future mission AMEGO
 - Other concept missions such as GECCO have proposed to use similar technologies

NASA Astrophysics tech dev grants
2009-2020

GRO
Spacecraft
Flown 1991



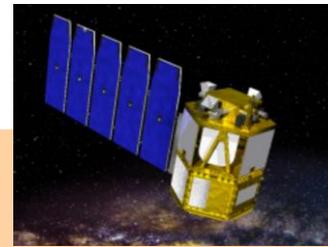
NCT
Balloon
Flown 2009, 2010



NCT Prototype
Balloon
Flown 2005



COSI
Long-duration balloon
Flown 2014, 2016, 2020



COSI SMEX
Spacecraft
Selected for launch 2025

AMEGO
Spacecraft
Pre-formulation (2028)



Sources:

<https://heasarc.gsfc.nasa.gov/docs/cgro/cgro/>

<https://cosi.ssl.berkeley.edu/>

https://science.nasa.gov/science-red/s3fs-public/atoms/files/Tomsick_cosi_apac_June2020_TAGGED_v2.pdf

<https://www.nasa.gov/press-release/nasa-selects-gamma-ray-telescope-to-chart-milky-way-evolution>

https://asd.gsfc.nasa.gov/amego/files/AMEGO_Decadal_RFI.pdf

Suborbital missions provide technology maturation, infusion, and transition opportunities

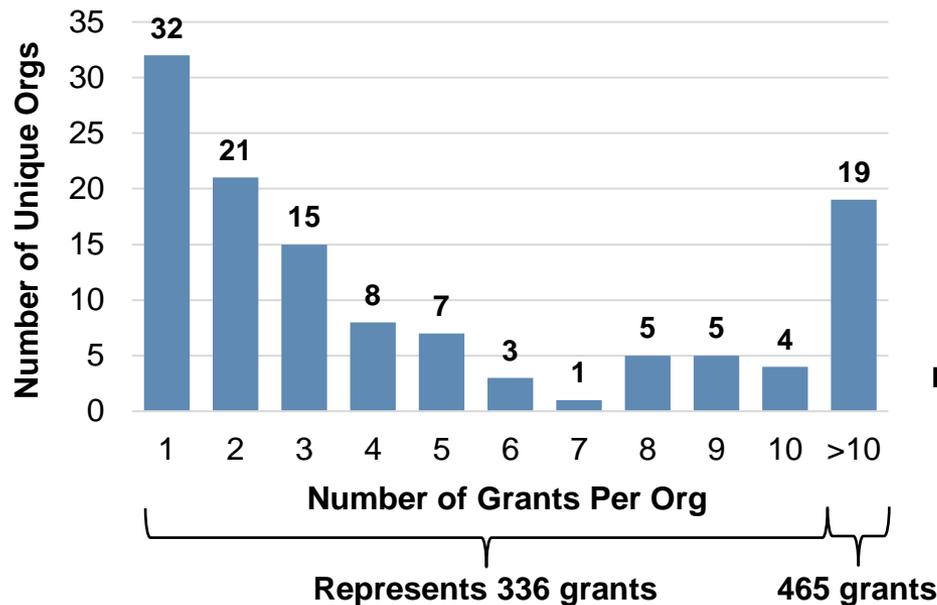


Organizational Analysis

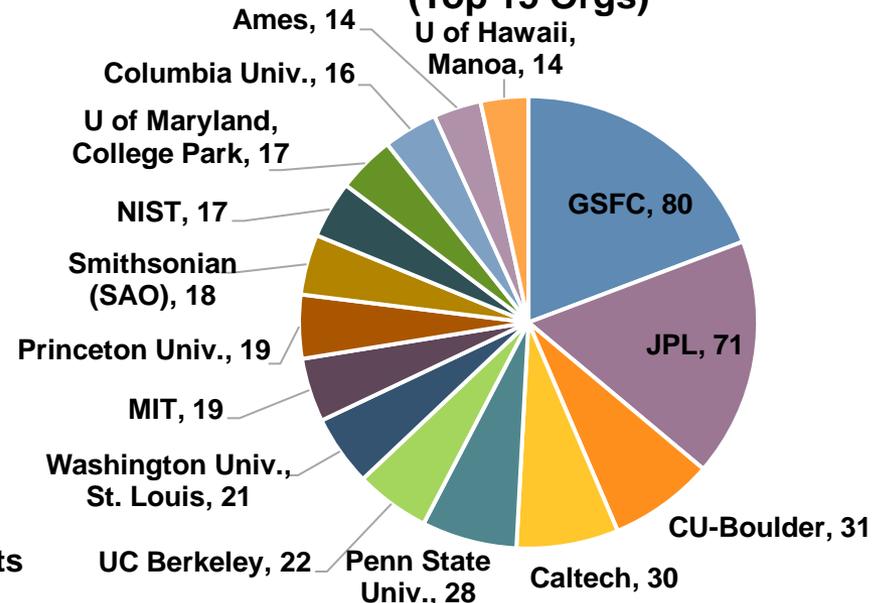
Astrophysics Technology Heritage Study 2010-2020

- Database includes a total of **120 unique organizations**
- Most organizations **received only one grant each**
 - **19 organizations received 58% of all grants** (465 of 801 grants)
 - GSFC and JPL top the list at 80 (10%) and 71 (9%) grants received, respectively, followed by CU-Boulder with 31 (4%) grants
 - **51 of 801 grants (6%) were received by minority serving institutions (MSI)**
 - U of Hawaii at Manoa and U of Arizona Tucson each received 14 grants (2% each)

Distribution of Grants Across Orgs



Grants Received Per Organization (Top 15 Orgs)





Summary

Astrophysics Technology Heritage Study 2010-2020

- This presentation represents a sampling of the most significant findings of the Astrophysics Technology Heritage Study
 - *Numerous other analyses were conducted and presented to NASA APD*
 - *Plan to publish more comprehensive results in a longer format paper in the future*
 - *Final report will be hosted on <http://www.astrostrategictech.us/>*
- Thank you to the over 300 PIs who participated in the study survey!
 - *Your feedback has been invaluable to NASA APD*
- Thank you to the full Aerospace Team for the tremendous effort!
 - *Kimberlee Sakai-Alvarez, Antonella Pinola, Uma Bruegman, Shirin Eftekharzadeh, and Francesco Bordi*
- Contact
 - *Marc Hayhurst, Senior Project Leader, The Aerospace Corporation, marc.r.hayhurst@aero.org*
 - *Mario Perez, Chief Technologist, NASA Astrophysics Division, mario.perez@nasa.gov*



Backup

Acronym List



Acronym List

- **Funding Programs**

- APRA Astrophysics Research and Analysis
- FINESST Future Investigators in NASA Earth and Space Science and Technology
- NESSF NASA Earth and Space Science Fellowship
- RTF Roman Technology Fellowships
- RTOP Research and Technology Objectives and Plans
- SAT Strategic Astrophysics Technology
- SMTP Segmented Mirror Telescope Program

- **General**

- APD Astrophysics Division
- CO-I Co-Investigator
- MIDEX Medium Explorer
- MSI Minority Serving Institution
- PI Principal Investigator
- SMEX Small Explorer
- TRL Technology Readiness Level

- **Missions**

- AMEGO All-sky Medium Energy Gamma-ray Observatory
- COSI Compton Spectrometer and Imager
- GECCO Galactic Explorer with a Coded Aperture Mask Compton Telescope
- GRO Gamma Ray Observatory
- NCT Nuclear Compton Telescope
- WISE Wide-Field Infrared Survey Explorer

Astrophysics Technology Development Portal



- NASA Astrophysics Division maintains a portal where additional information about individual grants can be researched as <http://www.astrostrategictech.us/>
 - *The portal houses the Tech Database, Tech Gap Priorities, and Additional Tech Dev Benefits*

Astrophysics Technology Development
PCOS, COR & ExEP Program Offices

Home About Tech Database Tech Gap Priorities Tech Dev Benefits

Welcome to the Astrophysics Technology Development Portfolio

This database is updated annually and indexes technology development projects funded by the NASA Astrophysics Division. The portfolio includes information about the Strategic Astrophysics Technology (SAT), Astrophysics Research and Analysis (APRA), and Nancy Grace Roman Technology Fellowship (RTF) projects, along with other competed and direct-funded technology projects.

Astrophysics is the science that studies the universe. The Astrophysics Division funds and manages missions and studies that seek to broaden our understanding of our place in the universe. This work addresses three big questions: How does the universe work? How did we get here? Are we alone? These three themes are managed by the Physics of the Cosmos (PCOS), Cosmic Origins (COR), and Exoplanet Exploration (ExEP) Programs, respectively. The breadth and scope of astrophysics can be summed up by simply saying that if it is located outside our Solar System, we are interested in studying it. Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.

Scope of Search

Funding Program	<input checked="" type="checkbox"/> SAT	<input checked="" type="checkbox"/> Directed	<input checked="" type="checkbox"/> Other	<input checked="" type="checkbox"/> APRA	<input checked="" type="checkbox"/> RTF
Portfolio Manager	<input checked="" type="checkbox"/> COR	<input checked="" type="checkbox"/> ExEP	<input checked="" type="checkbox"/> PCOS	APRA and RTF Portfolios are managed by HQ	

Project Status Active Completed

Search Clear All